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VOLUME X.—No. 5
MAY, 1945

32 VICTORIA ST
LONDON, SW1

SESSION 1944—1945

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THE LIGHTING OF BUILDINGS

By Dr. C. C. PATERSON, O.B.E., F.R.S. *(Fellow)*

(Chairman of the Lighting Committee of the Department of Scientific and Industrial Research.)

(Presented on Tuesday, February 13th, 1945.)

The issue of this report on The Lighting of Buildings* is a new departure of considerable interest to the Illuminating Engineering Society. It does not appear that the Society has previously participated in a complete study of the lighting of dwellings, although individual members have their own opinions on the subject.

This report, intended at least as much for architects as for illuminating engineers, was produced by a committee set up, on behalf of the Ministry of Works, by the Building Research Board of the Department of Scientific and Industrial Research. It forms one of a number of committees studying post-war building problems.

There were some twenty members on this committee, eight of whom were I.E.S. Fellows and six architects, who met twenty-four times from February, 1942, onwards. Two sub-committees, under the chairmanship of Mr. F. C. Smith and Mr. P. V. Burnett, reported respectively on the details of artificial lighting and natural lighting. Evidence was taken from a number of bodies, including the Illuminating Engineering Society, and from individuals. In addition a very full survey of conditions of lighting in dwellings was made by the Wartime Social Survey and the Building Research Station.

The resulting report occupies 164 pages, about half of which are devoted to appendices, and it is divided about equally between natural and artificial lighting. It covers both dwellings and schools. The procedure involved a preliminary study of existing knowledge and a survey of existing practice, followed by an assessment of suitable minimum standards, which were checked and finally fixed by the examination of installations in demonstration houses.

Lighting and Vision (Part I.)

The Report opens with an account of general factors influencing seeing, such as glare, contrast and colour, in a manner which should meet with the general approval of I.E.S. members. Some interesting comments on the effect of contrasts of light and colour on appearance are made on pages 10 and 11.†

Methods of Measurement and Principles of Design (Part II.)

Discusses in some detail the effect of window shape and arrangement in natural lighting of a building and methods of calculation. In addition to such well-known methods as the Waldram diagram described in Appendix 2 of the Report, a convenient method was devised based on the use of tables prepared by Mr. T. Smith of the N.P.L. A full set of such tables has been published and has, I understand, found considerable favour with architects. It should be borne in mind that the Committee was seeking not a precise method for detailed examination of existing rooms, but a quick and accurate method of calculating window shapes and sizes for a building existing only on paper.

This is followed by an analysis of building size and layout to determine the optimum conditions from the point of view of good daylight and sunlight. It is felt that this work may have a considerable effect on town planning.

Pages 32-38 give some methods of measurement for artificial light which conform with standard practice and include a comment on the supplementing of daylight with artificial

*Post-War Building Studies; No. 12, The Lighting of Buildings. (Published for the Ministry of Works by H.M. Stationery Office, London, 1944.)

†The numbers of pages mentioned are those in the Report issued by H.M. Stationery Office, mentioned above.

light. The Committee strongly deprecated the entire omission of natural light from buildings used for continuous working, but believed that artificial light of the right kind could form a suitable adjunct to daylight.

Lighting in Dwellings (Part III.)

In this section it is stated that "All habitable rooms in dwellings should have adequate daylight during normal daylight hours over a reasonable period of the year." Suggested minimum daylight standards are laid down for kitchens, sculleries, living rooms and bedrooms, and the possibility of obtaining these values in various densities of development is indicated. Sunlight in dwellings is also discussed.

Artificial lighting of dwellings is dealt with by quoting from the I.E.S. code and by recommendations for the size and positioning of light sources in the various rooms. It must be remembered that the recommendations were mainly concerned with "lower income group" houses where the cost of lighting is a very important factor, and that the values are regarded as minima. Thus kitchens with 100 watts of lighting power should reach 35 t.c. over half the area of the room and a higher value locally.

The survey (Appendix VI) showed that in electric-lighted houses (with an income up to £520 per annum) all but 2 per cent. of those examined used 75 watts or less in the kitchen, over one-third had 25 watts or less. In kitchen living rooms only 29 per cent. had more than 75 watts, and in sitting rooms less than 50 per cent. had over 75 watts, but there was clear evidence that the higher the income the more the light that was used and the better were people satisfied with what they had.

The Committee's recommendations, if adopted, will provide considerably more light than was shown by the survey to obtain at present. In kitchens up to 80 sq. ft. in area 100 watts is recommended. In kitchens between 80-120 sq. ft. 115 watts is recommended. Recommendations are given for light distribution, brightness and arrangement of fittings.

For living rooms the user is free to choose the type of light distribution he prefers and a chart is given to determine the wattage required. For a general fitting this works out at roughly 1 watt per square foot floor area: the provision of plug points and the value of moveable fittings are also discussed.

There was careful consideration by the Committee as to how it might be possible to ensure that the occupant of a house should have good lighting just as by law he is bound to get good sanitation. It was hoped that the powers given by the "Housing Act, 1936," might be fully used, and that, also, if houses were well equipped for artificial lighting when an occupier takes possession he would be encouraged to maintain his lighting in good order.

The Lighting of Schools (Part IV.)

In discussing the lighting of schools (Part IV.) the Committee considered that expense should not deter us from doing everything possible to prevent prejudice to the eyesight of children. Accordingly they required a daylight factor as high as 5 per cent., which will generally mean single storey buildings. Illumination under artificial light should be at least 12 foot-candles in normal classrooms and twice this value for partially sighted children. The brightness of fittings is controlled according to mounting height and recommendations are made regarding decoration and maintenance. Although the cost of complying with such recommendations would be high the Committee felt that it would be justified in view of the high incidence of eye defects known to develop during school age.

The remainder of the report proper deals with the Education of the Designer and the Lay Public (Part V.), Recommendations for Future Research (Part VI.) and a Summary of Conclusions (Part VII.), and then follows a most interesting series of appendices.

Survey and Analyses (Appendices I.—IV.)

Appendices I., II., III., and IV. deal with analyses of daylight and sunlight in buildings, covering the stan-

dard methods as well as some novel ones, and Appendix V. records a Survey of Daylighting in Flats. This shows that although generally windows were of the size now required by by-laws (i.e., an area of at least 10 per cent. of the floor area), the daylighting was, nevertheless, often inadequate. Appendix VI., which contains a Survey of Lighting of Dwellings, is one of the most interesting parts of the whole document. From these data the following main conclusions are drawn:—

(1) Many housewives had less artificial light than is needed for comfort and efficiency.
(2) The higher the income and the lower the cost of electricity the more artificial light was used.
(3) About one-third of the housewives thought they could see well by artificial light.
(4) About two-thirds thought they could see well by daylight.
(5) The use of artificial light was only important in the winter.
(6) In general dwellings were not planned in relation to aspect.

The significance of these results is evident and shows the great amount of work still to be done to improve the lighting of dwellings.

Cost of Improved Lighting (Appendix VII.)

Appendix VII. attempts an Estimate of Increased Costs Resulting from the Recommendations for Improved Standards of Artificial Light in Dwellings. In a kitchen of 80-120 sq. ft., the increased cost per annum is 7s. 6d. for electricity at 2d. per unit and gas at 1s. per therm. In a living room of 150 sq. ft., with a general lighting fitting, the difference is 15s. for electricity at 2d. per unit and 13s. for gas at 1s. per therm, per annum, assuming 1,000 hours burning. The cost of electric installation is increased by some £10 over pre-war prices, to include all the recommendations of the Electric Installations Committee (which includes all the lighting requirements) and for gas installation the corresponding increase over pre-war is given as about £6. The cost thus seems low, out of all proportion to the benefits to be derived.

The final appendix (Appendix VIII.) details Mr. P. V. Burnett's "Method of Measuring Insolation."

From the length and scope of the report it is evident that the Committee and its Sub-Committees did a great deal of work; nor must one forget the secretariat on whom inevitably falls a considerable burden. All this was only possible as a result of good team work and a ready willingness on the part of all members of the Committee to bring their best abilities to bear on the problem.

Activities of Sub-Committees on Natural and Artificial Lighting

The PRESIDENT (Mr. E. Stroud), having thanked Dr. Paterson for his address, then called up Mr. P. V. Burnett and Mr. R. O. Ackerley to give some account of the activities of the Sub-Committees dealing with Natural and Artificial Lighting.

Mr. P. V. BURNETT, Chairman of the Sub-Committee dealing with natural lighting, said that when they came to review available information relating to this subject it was found that there was a profound difference between the position of natural and artificial light. For artificial light there were well-established principles and a large number of text-books; for natural light not even the principles had been decided, and very little had been published giving the performances of an ordinary window. There were no standards of adequacy at all, the only established standard being of inadequacy, which could not form any basis for the design of post-war buildings. Also, the only available methods of calculating the performance of a window were not suitable for the purposes of the Sub-Committee, so a start had to be made from the beginning.

It was considered essential to establish standards for post-war housing and schools, and to evolve methods of attaining these standards, and, although the information available was not as complete as might be desired, the Sub-Committee took their courage in their hands and recommended some definite standards, for the first time in this country. More-

over, although the Sub-Committee would have liked more information upon which to form a judgment, it had the result of the survey of over 60 flats in which the opinions of occupants and observers were checked against calculations of the daylight available; there was also the work done previously by the D.S.I.R. and published in technical papers; there was all the parallel work on artificial lighting, including the I.E.S. Code, which formed a valuable guide; and finally there was the experience of the members of the Sub-Committee, none of whom were novices. The recommendations that have been made are believed to be reasonable and possible of achievement. These recommendations of standards are under three headings in each case: (1) intensity, (2) the area to be covered by that intensity, and (3) the depth of penetration into the room.

When methods of calculation were reviewed it was found that established methods approached the subject from the point of view of calculating the amount of daylight that would pass through a given window. The Sub-Committee's point of view, for the design of post-war buildings, was the reverse; a method of calculating the dimensions of a window through which a given amount of light would pass was wanted, and in achieving this object it was greatly assisted by Mr. T. Smith, of the National Physical Laboratory, who evolved a simple formula for making the necessary calculation, and which could be used to prepare tables of window performance under given conditions. These tables, Mr. Burnett added, have now been published, and he regarded them as the biggest step forward in the science of natural lighting that had been made for many years. In common with all other work to do with natural light, they involved certain approximations, but for the purpose for which they were intended they were reasonably accurate and provided for the first time a scientific basis upon which a designer could find his window sizes without laborious calculation.

The amount of daylight passing through a window depended not only upon the window itself but also upon external obstructions to the sky caused by other buildings, trees, etc., and the report contained an interesting analysis of these external obstructions. It was shown that the usual hollow squares of buildings on a grid road plan did not provide good daylighting, and that by so planning the buildings that the internal areas become external, so that the buildings become cruciform in shape, the buildings become more widely separated, and the daylight improved substantially. This was, of course, a town-planning matter, and showed clearly how the sciences of natural lighting and town-planning were interdependent. Also, the report demonstrated that on a given grid road plan, low buildings did not give such good daylight conditions as higher buildings of the same total floor area, but smaller in plan, and therefore more widely separated. It was, of course, realised that other factors had to be considered, and the recommendations only pointed out the daylight advantages.

The Report also dealt with sunlight, made recommendations for limits of orientation, and described methods by which the entry of sunlight into buildings could be calculated. There was an interesting section relating to sunlighting the ground around buildings and the general distribution of sunlight, but there was much information available about this subject previously, and the Report did not take the matter much further.

When the Sub-Committee came to consider schools, they were appalled by the evidence of eye-defects in school children. Whereas some 10 per cent. of children had eyesight defects upon entering schools, when they left the percentage had risen as high as 25 per cent.; no fewer than 15 per cent. of the children developed eye defects whilst at school. Whilst there were probably a number of reasons for this other than lighting, nevertheless the Sub-Committee were definitely of the opinion that the old standard of fenestration which worked out to a minimum of 0.5 per cent. d.f. was far too low. As it was informed that most post-war schools would be of single-storey design, permitting roof as well as window lighting, a number of different designs were examined, and it was found that there should be

no difficulty in providing far higher standards than in the past. The Sub-Committee recommended 5 per cent. d.f., no less than ten times the old standard, and had shown that this high standard can be achieved in practice.

Finally, the Sub-Committee on natural lighting considered that the Report should be used as a whole, and they supported in every way the recommendations of their brother Sub-Committee on artificial lighting; because it was no good a building having good natural lighting unless the artificial lighting was of an equivalent standard, or vice versa.

Mr. R. O. ACKERLEY, who introduced the Section of the Report dealing with artificial illumination in the absence of the Chairman of the Sub-Committee, Mr. F. C. Smith, said that unlike natural illumination there was a great deal of already published material concerning artificial lighting which was recognised standard practice. Therefore, the general principles of design had not taken up nearly so much of the Report as was the case with daylight. In this respect, the only new point brought out in the Report was that mentioned by Dr. Paterson, viz., the use of artificial light as a temporary or continuous supplement to or substitute for daylight. In this respect the Sub-Committee after considerable deliberation, had made certain recommendations, and one of the subjects suggested for further research was this particular problem of supplementing daylight with artificial lighting. Before making these recommendations, the Sub-Committee saw a number of installations in which daylight and artificial light were blended together, and they were satisfied that so far as the future was concerned there was a very potent weapon in the fluorescent lamp which, so far, had only been used in industry.

He emphasised what Mr. Burnett had said, viz., that the reports of the two Sub-Committees should be read together. They were both unanimous that to make buildings without any daylight at all should not be considered and should be avoided if it possibly could. At the same time it was recognised that in certain areas and certain buildings the daylight was, of necessity, inadequate, and that it was practicable to supplement the daylight permanently with artificial light, provided some daylight was coming in—which had a very great psychological effect.

The values of illumination, which Dr. Paterson had mentioned, might at first sight appear very low, but personally he was not so sure that they would appear low on further consideration. The I.E.S. Code set out certain standards for kitchens, etc., and there were certain working parts of the kitchen where these standards of illumination should be applied. As regards kitchen lighting, the Sub-Committee had tried to make the point that a kitchen should not be lighted with a single fitting, which meant shading a portion of the room. Therefore the recommendation was that there should be *two* points, with a given total candle-power split between these two points. In that case, the practical illumination at the actual working places was very close to, if not up to, the I.E.S. Code.

In regard to all these recommendations as regards dwellings, a considerable number of practical tests were carried out and none of the recommendations were made purely on paper calculations. They were the result of tests, and although perhaps they did not come up to what the members of the Society would like, they were not at all bad and infinitely better than the standard practice in the past.

In addition to two lighting points in the kitchen, it was recommended that the brightness should be limited, and that there should be a standard of distribution and a standard of efficiency in order to ensure that the light was really where it was wanted.

The lighting of living rooms was a very difficult problem and it had not been possible to make any recommendations with regard to actual fittings to be used. Even if the Sub-Committee could have agreed—and he was sure they could not—no recommendations on this matter could have been put into the Report. It was necessary to avoid glare and to have enough light to give reasonable efficiency. The Report pointed out that standards of brightness could be laid

down and that it was easy to arrive at a minimum efficiency value which would protect the public from paying for a lot of light which was not used. As regards illumination, they had tried to work from first principles. The Report suggested that in rooms of this kind a utilisation factor could be assumed which would apply fairly generally to all classes of room in relation to fittings of certain general classes, namely, mainly direct, mainly indirect and general lighting fittings. A chart recommended wattages for each class of fitting in relation to the areas to be dealt with. By this method there was 100 per cent. freedom in the choice of the type of fittings which could be used. In living rooms there must be general lighting with supplementary lighting to enable specific jobs to be carried out in the home, but it was not possible to make recommendations as regards the supplementary lighting. The use of portable lights must be left to the householder, but there should be sufficient facilities by way of points and it was for this reason the Report made recommendations for additional outlets. Lighting points had also been allowed for in bedrooms to supplement the general lighting.

The lighting of schools was standardised closely in accordance with the Report prepared some years ago by the Illuminating Engineering Society, and there were no outstanding points in this connection which called for comment. Whereas in the average place the normal line of vision was downwards, in a school it was horizontal because the pupil, for a good deal of the time, was looking towards the teacher and the blackboard. This accounted for the differences in the recommendations as regards brightness of fittings in school as compared with the home and other places.

Welcome to Dr. N. A. Halbertsma

The PRESIDENT, before calling upon Mr. J. S. Dow to open the discussion, mentioned that there was present at the meeting Dr. N. A. Halbertsma, who was President of the International Illumination Commission when it met in Holland shortly before the war, and had done so much for illuminating engineering abroad. Dr. Halbertsma had just come over from Holland, where he had suffered the privations of war. They were all extremely glad to have Dr. Halbertsma safe amongst them and hoped that he would say a few words to those present. (Applause.)

Dr. N. A. HALBERTSMA (Holland) then briefly addressed the meeting and expressed his gratitude for the welcome he had received. He said that although he was President of the International Commission on Illumination, he was not in this country for that purpose because its work had not been resumed. He could say, however, that the building at Arnhem, where the Reports of the international conferences were deposited, was still standing although the battle had raged around and near this building. After the war, it was to be hoped that the work of the Commission would be resumed as soon as possible. He hoped it would not be very long delayed. In the meantime, some work had been carried out in Holland especially in connection with the blackout, and interesting work had been done at the Laboratory on the lighting of factories, notably by daylight. Work had also been done on the efficiency of artificial lighting fittings; it was found that the range of efficiency varied considerably—between 15 and 60 per cent. The Report which was to be discussed at the present meeting was aimed at protecting the ordinary user of artificial lighting, who, in the future, should have some guarantee that he would not have to be content with an exceedingly low efficiency. In the meantime, under war conditions in Holland, a great use had had to be made of 25-watt lamps. He himself had been living in one room heated by a small stove. In many cases the problem of lighting had had to be solved by a sub-division of the 25 watts, and lamps of 7½, 9 and 12-watts had become quite customary.

In conclusion, he expressed the hope that the time would not be long before Holland began to rise again after the destruction that had taken place of houses, factories, transport and, indeed, nearly everything. (Applause.)

Discussion

Mr. J. S. DOW, in opening the discussion, said that he would like to draw

attention to several main tendencies in the Report, which was noteworthy for the fact that natural and artificial lighting were considered in relation to one another and not as entirely different entities. Architects and illuminating engineers were coming to appreciate common principles could be adopted in dealing with both forms of lighting and values of illumination correlated.

Another feature was the emphasis placed on methods of decoration and the influence of the colours of walls and ceilings on results. Certainly planners of lighting schemes in the future would expect some say in the style of decoration and the surround to what was termed the working area.

Members of the Society would be keenly interested in the recommendations in regard to school lighting. His own interest in this subject dated from the early days of the Society, when he took measurements of illumination in many schools, including some of the most famous, where, incidentally, the lighting was found to be exceedingly bad. It was one thing, however, to make recommendations and quite another thing to get them carried into effect. It appeared that, even when educational or local authorities made good recommendations on lighting, the architects or other experts concerned had usually far too much to do to study proposals for lighting in any detail. Moreover, apart from State-aided schools where supervision of the lighting was nominally approved, there was often no check whatever on what was done in schools run by private bodies. The recognition in the Report that in future some form of central control, applicable to *all* schools, was necessary was, therefore, of vital importance.

It must also be remembered that, whilst on the whole artificial lighting in new schools was fairly good, such schools might form less than 5 per cent. of the total in use—and in old buildings it was difficult to do anything about the natural lighting.

With regard to private houses, it was doubtless true that the Englishman's home was his castle. The Report, however, only aimed at securing that he should not be debarred from the chance of getting adequate lighting. The statistics in regard to cost were very informative. In the background there was the question how far values of illumination should be settled by economic considerations. If it were true, as recent surveys had suggested, that where the family income was under £3 a week not more than 1s. a week was spent on lighting, how could it be ensured that the lighting would be adequate?

In conclusion, Mr. Dow remarked that there were some people who were opposed to any measure of control, on principle. Experience during the war had shown that the factory lighting regulations had been beneficial. He believed this would apply in other fields.

As regards the objection apt to be raised against any material rise in values that it was "wasteful," Mr. Dow recalled the progressive advances during the history of the Society and the report of one of its committees, which, in 1913, recommended only 3 foot-candles for the lighting of classrooms; even this modest value, however, was considered extravagant by some members of that committee, who put in a minority report in favour of 2½ foot-candles!

Since those days the valuable work of Mr. Weston and others had revealed the benefits of higher illuminations and provided a scientific background to the I.E.S. Code. Nevertheless, advances were, in practice, determined largely by improvements in the efficiency of illuminants rather than by theoretical considerations—so that those who tried to call a halt to the rising standards of illumination were fighting against the stars in their courses—or should it be said, the lamps in their sockets?

Mr. P. J. WALDRAM said the Report appeared to be in flat contradiction to the policy of the Society as regards natural lighting as laid down in its Lighting Reconstruction Pamphlet No. 4. This pamphlet frankly admitted there was much to be done before we could afford to be dogmatic with regard to scientific fenestration.

This was very true. However much might be known about the bare necessity ration, which alone was protected by legal rights of light, little or nothing was known, before the war, about generous natural lighting. We did know, however, that a variation of over 90 per cent. from the front to the back of a well-lit room would often be estimated at about 10 per cent. by experienced observers. This was assumed to be due to logarithmic reactions—but had this ever been proved?

He confessed to a decided preference for the attitude of that pamphlet—which called for further enquiry and research when there was time for it—rather than the uncompromising finality of the present Report which tended to petrify everything into final codes of practice and discourage

future research by purporting to say the last word on so many problems.

He did not propose to make any comments on the Report with regard to artificial lighting. Architects who had to make the final decisions with regard to post-war buildings would decide whether it represented essentials or extravagance by matters within their own knowledge, such as the stipulation that very small kitchens and sculleries less than 80 sq. ft. in area must have 100 watts.

On the remainder of the Report he made two criticisms, not because there were not others that could be made but because these two were so important and far-reaching that unless they could be answered completely, the whole Report was suspect. Those who could make two errors, if they be errors, could make others.

The first point related to the natural lighting of school classrooms. In 1914 a Committee of the Society reported that in good modern classrooms, really well lighted by ample high windows facing large open playgrounds, the worst desks enjoyed an average of 0.5 per cent. daylight factor. Subsequently, this figure proved to be identical with Continental Government requirements for schools and for years it had remained as the only published measured data with regard to generous amplitude of natural lighting. This Report and the new Code, however, called for a minimum of ten times that amount and required that wherever that could not be obtained the deficiency should be made good by reinforcement with artificial lighting kept in continual use. No indication was given of the cost of these revolutionary requirements. In capital and maintenance it must be, in the aggregate, colossal, and to many authorities the cost of education was already very severe.

But the cost did not stop at lighting. The Committee had come to the strange decision that all requirements as to insolation must be measured by ability to admit a fixed period of possible (even if highly improbable) sunshine in midwinter, viz., December 22, irrespective of what happened during the remainder of the year. To the cost of abnormal fenestration—which, incidentally, involved extra heating in winter—and continuous artificial lighting, must be added the cost of installing and running electric fans to keep the temperature down to reasonable limits during the many hours of hot sunshine in summer entailed by such orientation that all classrooms must face approximately south. There was no medical or educational opinion cited in support of this and, indeed, it was surprising to find that the Report on this matter was merely the result of an investigation on drawings into the possibility of increasing light by clerestory windows. Again, in their solicitude for mid-winter morning sunshine, the Committee recommended that all kitchens should face approximately south. As larders generally adjoined kitchens this ruling should evoke enthusiastic support from the makers of refrigerators!

His second major criticism related to the N.P.L. Tables of window efficiency which purported to give the depth back from the window wall and the area of the elliptical zone of horizontal table area at cill level to given daylight factor values by single rectangular windows, both unobstructed and facing continuous horizontal obstructions or their practical equivalents subtending given angles of obstruction. By a strange oversight, these degrees of obstruction were defined by the angles which they subtend at the window cills, an old-fashioned convention long since discarded by architects and the Courts as having no practical meaning without particulars of either or the distance of obstruction. Immediately the N.P.L. Tables were published he had pointed this out to the B.R.S. but the official reply was to the effect that obstructions had been assumed to be sufficiently distant to subtend virtually the same angle at the cill end and inside the room, any error involved being on the safe side. This could only mean that the Tables had been calculated for angular obstructions extending to virtually infinite distances and therefore to virtually infinite heights. They thus exaggerated the real effect of all degrees of obstruction and thereby called for excessive glass area to comply with any specified functional requirement; the excess being either immaterial, material or absurd according to circumstances. This particular criticism had, with others, been on record for some time in the technical press, and in the journals of the R.I.B.A. and of the Chartered Surveyors' Institution, but so far as he was aware no attempt had yet been made to answer it on its merits.

To be of any practical use, criticisms of this Report ought to have been made months ago; it was probably idle to expect that the powers-that-be would alter the draft codes and thereby weaken them by the tacit admission that they were not perfect when first drafted.

Mr. C. HARVEY said he had been

much impressed with the work which the Society had done. In this case they had made a constructional effort, which was all to the good. It was impossible to be perfect, but the recommendations in this Report were well thought out. He had carried out many school lighting installations and, twenty years ago, it was his endeavour to adopt a minimum value of 15 foot-candles. This was considered to be absurd, but he still held to that view and, indeed, several people believed that the value should be still higher. Undoubtedly the question of cost in the homes of the lower wage-earning classes was a great difficulty, but that should not prevent the Society laying down the minimum value that should be aimed at.

Mr. E. W. GODDING, referring to the physiological aspect, said it was only in comparatively recent times that man had had to accustom himself to working with artificial illumination. Before that most of his activities were carried out in daylight at very much higher levels than were generally attained with artificial lighting. In the past, man had suffered considerably from inadequate artificial lighting, but now the gap between outdoor illumination and indoor illumination was being slowly but surely decreased. He regarded this tendency towards higher standards of internal illumination as being based on physiological requirements, and therefore was all to the good.

Mr. A. CUNNINGTON said that in a case where he had to move some compositors from a bomb-damaged building to another not very well lighted, he mixed artificial light with daylight, using fluorescent tubes for the purpose. The results were very successful. The compositors, who had a severe visual task, did not experience any difficulty, and he thought it feasible to adopt some automatic type of control which would bring the artificial lighting into use progressively up to a prescribed value of illumination when daylight failed.

On the general question, he said he felt a little concerned lest the present valuable Report should meet the fate of those early Bluebooks of 1913 on Factory Lighting, which contained so much information but came to nothing at the time. He hoped we should not have to wait 25 years before effect was given to the present Report. It was our tendency to lead rather than to drive, but the recommendations in this Report were so moderate that in some cases, such as for schools, it should be possible to make many of them mandatory. He thought this would be welcomed by the more progressive educational authorities, and hoped that early positive action would be taken.

Mr. M. W. HIME welcomed the Report as a valuable contribution to lighting literature, and as he was a member of one of the sub-committees in Scotland which was preparing a Report on Schools, there were one or two specific items in connection with the lighting of schools he would like to raise. He stated that he was quite happy with regard to sunlight in schools given on page 67, but found it difficult to reconcile the statement with the comments on the Heliodon given on page 94, which admittedly applied to an office block, employing a recommendation for the siting of buildings east and west. Bearing in mind conditions north of the Border, the positioning of schools, due to the short days of winter, was probably even more important than down South, and he felt that the positioning of school buildings should conform to that given on page 67. Such a divergence between these two recommendations might be confusing to educational authorities and town councillors.

Paragraph 254 seemed to give too great a tolerance, as in experiments carried out in Scotland the point had been brought out that it became necessary to light the whole of the classroom area, and not confine a recommendation to an area where the lighting engineer thought the desks might be placed. Different teachers preferred different lay-outs of desks, and the diversity permitted under paragraph 254 should be reduced. This could be partly accomplished by altering the word "minimum" to "maximum" in the last line of the paragraph.

Finally with regard to schools, he would have preferred the lighting of staff rooms to have been a general level of 12 foot-candles and not 6 foot-candles, with local lighting in addition.

A further point raised referred to the fact that apparently no reference was made to 5 foot-candles being the "grumble point" as far as illumination values were concerned, and whilst appreciating the difficulty in obtaining higher levels in working-class houses, nevertheless felt that lighting conditions would be better in the bedroom than in the living-room, as envisaged in the Report.

Mr. R. W. HUNT said that whilst agreeing with the first part of paragraph 101 with regard to combining

artificial light with daylight, he did not feel that sufficient weight was given to the importance of providing artificial light as a temporary or continuous supplement to daylight. In the larger buildings—in many schools, in fact—the situations in which the necessity for a satisfactory blend of artificial light with daylight did not arise were comparatively few and it was necessary at some time or other to supplement daylight with artificial light. In other words it seemed desirable for the artificial lighting of nearly all buildings to comply with Part 2 of paragraph 102. Therefore, in most instances, the major aim in the design of a lighting installation might well be to provide artificial light to augment twilight conditions satisfactorily, with the secondary aim that the same artificial lighting will be sufficient and suitable when there is no daylight. If this point of view was accepted, then, among other things, much more attention would have to be paid to colour correction of light emitted from most sources used for the lighting of buildings, and this should be welcomed as a progressive step.

He would like to see Methods of Design (page 35) prefaced by a warning that a prime consideration should be to ensure that the colour and diffusion of the artificial light were such that it would blend with daylight.

The statement in paragraph 246, page 66, under the heading "Combination of Artificial and Natural Light in Schools," was too mildly expressed. Surely the study should drive home that in schools, at least, artificial light which combined well with daylight should be provided as a matter of course and not that it should be merely regarded as advantageous, as stated. Paragraph 253 (f), on page 68, met the case better, but, here again, would it not be better to reverse the order and make the supplementation of daylight the more important feature.

He offered these suggestions mainly because he felt that attention to the question whether lighting conditions in schools contributed to the development of eye defects in children during school life should be focused on this aspect.

Mr. J. B. Carne (Communicated):—Before raising two points of criticism which come to my mind in reading the Report, I would indeed convey a wrong impression of my appreciation of the Report if I did not at once express my view of its high excellence. Not only is it admirably practical in character, but it is a sorely need contribution to the classic literature on the subject, particularly regarding natural lighting.

My first point concerns "sunlight." It seems very odd to find in paragraph 65 that the committee is not fully convinced that sunlight is desirable in buildings, although in paragraph 69 they are quite sure it is essential to vegetation. Of course sunlight is very desirable in any place where humans live. Medical science has provided unquestionable evidence that it is good for human growth and that ultra violet "kills" the influenza virus, while we all know that the infra-red in it will warm our buildings and their contents free of charge.

I regret the damning by faint praise of sunlight, especially in an era when the trend is artificiality at every opportunity.

My other point concerns the recommendation contained in paragraph 209, which aims at raising the standard in quality of the artificial lighting of dwellings. I am entirely in sympathy with the aim, but I feel that a far more widespread benefit could result from making available a range of tax-free Utility lighting fittings, by which I mean the light distributing component—the bowl or the shade—than from enforcing the installation of approved fittings in new houses and making them part and parcel of the house. I do not think it practical or wise to regard the part of a lighting fittings which effects the distribution as a landlord's fixture, owing to its portability, its decorative nature and its relatively small cost.

Landlord's ownership would discourage the user's interest and restrict his choice of design. Freedom to purchase anywhere a fitting bearing a "hallmark" of approved performance and quality, and possibly tax-free, would benefit not only the four to five million new householders, but also automatically raise the quality of the lighting in the twelve million existing houses.

I think that a recommendation to this end by the committee would have been desirable.

Mr. P. V. Burnett: Mr. P. J. Waldram referred to "two errors" in the report, the first being the recommendation that school classrooms should have a standard of 5 per cent. daylight factor. Part IV. of the report gives some particulars of the increase of eye defects in children during their school years which, to most people, will be something of a shock, and if it be an

error to wish to do everything within the power of the school designer to see that post-war schools have sufficient natural light to remove any possibility of these eye defects being caused by insufficient daylight, then we are glad to have made such an error. But is it an error at all? We know from personal inspection of schools that classroom desks having the old minimum standard of 0.5 per cent. daylight factor were insufficiently lighted for a large part of the year; we know that post-war schools will mainly be single-story buildings, and we have shown that far higher standards can be obtained in such buildings; and we know that the tendency for many years has been for standards of natural and artificial light to be raised, so is it surprising that in 1944 we should recommend higher standards than those which resulted from work done in 1914?

Mr. Waldram's second "error" relates to the tables of window performance produced by the N.P.L. with the encouragement of the Committee. In this case the error is stated to be that angles of obstructions are defined as being subtended to the sills of windows instead of to the heads. I am sorry that Mr. Waldram should imagine that the Committee should overlook such an obvious point; we did not do so at all, and were fully aware of the criticisms that could be made. But these tables were intended for the use of designers of buildings, and in the early stages of designing the position of the sill of the windows is known, whilst the position of the head is not not. To provide tables giving angles of obstructions subtended to the head of windows might be more accurate mathematically, but would be of little or no use to a designer; if the position of the head of a window is fixed before the lighting performance is considered, then there only remains the width to vary according to circumstances, which would not only give some very strangely shaped windows, but no architect would do it at all, because proportion, so important aesthetically, would have gone from his control.

Nevertheless, it is correct that angles of obstructions subtended to the sill do lead to inaccuracies when dealing with near obstructions, but it must be remembered that we are not dealing with an exact science, and the tables are sufficiently accurate for all normal purposes for which they are intended. The whole science of natural lighting is based upon approximations and averages, some of which were originated by Mr. Waldram in his pioneer work, and if the approximations in these tables are errors, then the science of natural lighting is thick with such errors. It does not help to test these tables with obstructions either 6 ft. or 6 in. distant; in post-war housing we hope that there will not be any obstructions so close to windows. Finally, with regard to the criticism that the tables are useless for schools, their title is "The Natural Lighting of Houses and Flats with Graded Daylight Factor Tables," and they are becoming a best-seller.

A question was asked as to whether the recommendations for sunlight in schools would be applicable to Scotland. This point had been considered, and the recommendations would be quite suitable for Scottish latitudes up to 57 degrees N.—say, the region of Aberdeen. Farther north it would be advisable to limit orientation to E.S.E.-W.S.W.

Dr. C. C. PATERSON, commenting briefly on the discussion, said that one thing which impressed itself upon him was that one of the most important things immediately ahead was planning together the artificial and natural lighting of schools. In answer to Mr. Waldram, he pointed out that with the old efficiency of electric lighting it would have been very expensive to carry on continuous artificial lighting during the hours that natural lighting of schools was ineffective. Now, however, that the amount of energy required for a given amount of lighting had been divided by 3, the position was very different and he hoped that the end in that respect had not yet been reached.

In conclusion, Dr. Paterson expressed his appreciation of the congratulations which had been offered him at the opening of the meeting by the president on being awarded the Faraday Medal by the Institute of Electrical Engineers.

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

With a view to avoiding possible confusion with other publications, reference to these Transactions should be in the form :—" Trans. Illum. Eng. Soc. (London)."

SESSION 1944—1945

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Sessional Meetings in London

A joint meeting took place with the Royal Institute of British Architects at the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1) at 5.30 p.m. on Tuesday, February 27, 1945, when the chair was taken by the president (Mr. E. Stroud).

After the minutes of the previous meeting had been taken as read, the president called upon Mr. Percy Thomas, president of the Royal Institute of British Architects, to make a few remarks, following which Dr. J. W. T. Walsh was invited to present his paper, entitled "The Relationship between Interior Design in Building and Artificial illumination."

In the ensuing discussion Mr. A. H. Barnes, Mr. W. E. Bush, Mr. P. V. Burnett, Mr. A. Cunnington, Mr. W. J. Jones, Mr. Howard Long, Mr. Anthony Potts, Mr. W. T. Souter, Mr. H. C. Weston, Mr. Hartland Thomas, and Mr. William Allen took part.

After Dr. Walsh had briefly replied to the discussion, the proceedings terminated with a vote of thanks to the author.

A joint meeting with the Royal Meteorological Society was held at the Imperial College of Science and Technology, South Kensington, on Wednesday, March 21, when the chair was taken by Mr. Gordon Manley (president of the Royal Meteorological Society).

After the chairman had extended a cordial welcome to I.E.S. members and Mr. E. Stroud had returned thanks, Mr. J. M. Waldram read a paper entitled "Measurement of the Photometric Properties of the Upper Atmosphere," in which he described in detail the special instruments which had been designed and the methods of measurement, and assembled the results of the experiments in tabular form.

In the ensuing discussion Sir George Simpson, Dr. C. C. Paterson, Mr. Percy Good, Mr. J. W. Ryde, Wing-Commander R. M. Poulter, and Dr. A. R. Meetham took part. After Mr. Waldram had briefly replied to the discussion a vote of thanks to the author terminated the proceedings.

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The following applicants have been duly elected by the Council to membership in the Society, and their names have been added to the list of members:—

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Printed by ARGUS PRESS, LTD., Temple-avenue and Tudor-street, London, E.C.4. England